When is foreign exchange intervention effective? Evidence from 33 countries

Marcel Fratzscher, Oliver Gloede, Lukas Menkhoff, Lucio Sarno and Tobias Stöhr

Abstract

This paper examines foreign exchange intervention based on novel daily data covering 33 countries from 1995 to 2011. We find that intervention is widely used and an effective policy tool, with a success rate in excess of 80 percent under some criteria. The policy works well in terms of smoothing the path of exchange rates, and in stabilizing the exchange rate in countries with narrow band regimes. Moving the level of the exchange rate in flexible regimes requires that some conditions are met, including the use of large volumes and that intervention is made public and supported via communication.

JEL-Classification: F31, F33, E58.

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Foreign exchange (FX) reserves of central banks have accumulated to the highest level ever seen in recent history, in absolute terms and in relation to GDP. This accumulation of FX reserves raises concerns about global imbalances in the world economy (e.g. Jeanne and Rancière, 2011) and about the potential for "currency wars" (see Eichengreen, 2013). At the same time, central bankers generally believe in FX intervention as a useful policy tool (Neely, 2008). The last global financial crisis has shifted the focus even more towards smoothing exchange rate fluctuations to limit FX volatility (Mohanty and Berger, 2013; Blanchard et al., 2015), and recent theory claims that interventions may be welfare enhancing (Gabaix and Maggiori, 2015; Hassan et al., 2016; Cavallino, 2017).[1]

We take these facts and policy concerns as motivation to examine the effectiveness of FX intervention in a systematic manner. We try to overcome the reliance of the extant empirical literature on small samples consisting of only a single country or a few countries. Due to this data limitation, lessons learned necessarily refer to specific circumstances which are difficult to compare across countries and thus tend to have low external validity. By contrast we examine a broad cross-section of countries in order to draw general lessons and detect the determinants of (more) effective FX interventions. Accordingly, we compile a new dataset on daily FX interventions by 33 central banks which comprise both actual interventions and communication about FX interventions.

This dataset is crucial for our study, because the bottleneck of research on FX intervention has long been data availability. Many studies have to rely on press reports about central bank intervention (Fischer, 2006) or use intervention data of single countries directly provided to the researcher (e.g., Fischer and Zurlinden, 1999). Only a few central banks publish their intervention data and therefore have been intensively studied by academics. However, this pool of available data is small and composed mainly of advanced economies. Thus studies either cover just few countries (such as three countries in the influential study by Dominguez and Frankel, 1993) or have to rely on lower quality data, such as weekly aggregates, or on proxies of actual intervention amounts, such as the change in foreign reserves (e.g., Adler and Tovar, 2011; Levy-Yeyati et al., 2013; Daude et al., 2014; Adler et al., 2015).

Our data come from 33 central banks, of which 23 central banks do not make their data publicly available. Reliable daily intervention data, covering only sterilized interventions, stretch over a maximum period from 1995 to 2011.

[1] See also the surveys on FX intervention by Edison (1993), Sarno and Taylor (2001), Neely (2005), and the recent studies of Adler and Tovar (2011), Levy-Yeyati et al. (2013), Daude et al. (2014), Adler et al. (2015).

This dataset has some overlap with a few other studies on single countries or small groups of countries; otherwise it opens a new universe that allows us to establish stylized facts, examine key differences across countries and exchange rate regimes, and distinguish the relative importance of FX intervention determinants across countries.

The first step of the analysis is the description of intervention behavior through the lens of our new data. Due to the broad coverage of the sample we can provide a more representative picture about intervention characteristics than is common in the literature. The dataset consists of almost 114,000 trading days. On these days the sampled central banks intervened, on average, on 19.1 percent of days. This may be surprisingly frequent with the recent experience of the major advanced economies in mind, in particular when considering that the U.S. Federal Reserve and the European Central Bank hardly intervene in FX anymore. However, many central banks, in particular in emerging and developing economies, intervene frequently.

Our main finding is that exchange rate intervention is an effective policy tool according to different criteria used to judge the success of FX interventions. We use several different success criteria, building on the work by Fatum and Hutchison (2003) and Fratzscher (2008). These criteria look at the directional change of the exchange rate on the day of an intervention as well as the volatility and stabilization during subsequent days. Generally, we find fairly high success rates of FX interventions, contradicting those studies nurturing skepticism against the usefulness of interventions (e.g., Schwartz, 2000). Moreover, this finding is methodologically far from self-evident in a large cross-section of heterogeneous countries, given their different intervention objectives. Specifically, it is key to apply different success criteria that distinguish between currency regimes with more exchange rate flexibility and those with limited flexibility (i.e. a narrow band of exchange rate variation) to reflect the difference in policy objectives of the intervening authorities.

It is only for the more flexible regimes, dominating in advanced economies, that the conventional effectiveness measures (e.g. moving the level of the exchange rate) are fully appropriate. Regarding countries with narrow bands, however, it seems more suitable to measure effectiveness relying mainly on a success criterion which reflects the fact that stable exchange rates constitute the intervention objective for these countries' authorities. We rely on three success criteria in our analysis to capture different intervention objectives: the ability of intervention to change the direction of the exchange rate ("event" criterion), the ability to smooth the path of the exchange rate ("smoothing" criterion), and the ability

of intervention to stabilize the exchange rate to keep it in a narrow band ("stabilization" criterion). While these criteria and the underlying objectives can be mutually consistent, they capture different aspects of intervention effectiveness and our results indicate that they are far from being perfectly correlated.

Based on these criteria, we find that an 80 percent success rate of FX interventions is actually a fair description of past policy. The high effectiveness of interventions can most easily be recognized from the smoothing criterion, because such a dampening of earlier exchange rate changes works in about 80 percent of cases, basically independent of the exchange rate regime and the empirical specification. Regarding the stabilization criterion, the success rate across all countries and episodes would be misleading because often (obviously in floating regimes) there is no ambition to strictly keep exchange rates within narrow limits. However, when focusing on countries with narrow band regimes, the success rate is at least 80 percent and can be further improved under certain conditions.

Finally, regarding the conventional effectiveness criteria typically used for floating exchange rate regimes, i.e. moving the exchange rate at the "event", the baseline success rate is only about 60 percent. Thus paying attention to the conditions of interventions is important. Interventions tend to be more effective (i) if they are large in size, (ii) are executed in line with the prior exchange rate trend, and (iii) towards longer run fundamental equilibrium. Moreover, we find that appropriate communication of authorities can enhance effectiveness. Intervention is more effective in terms of the event criterion if it is accompanied by oral intervention and if oral intervention occurs during turbulent times.

We make some effort to deal with the endogeneity of interventions, regarding their existence and the termination of intervention episodes. Still, we may underestimate intervention success in periods where central banks intervene against strong exchange rate trends, to provide an obvious example; this is particularly important because most interventions are “leaning against the wind”. More generally, we are aware that our procedures are better understood as reduced form rather than structural estimations.

Overall, our main contribution to the literature is the systematic analysis of determinants of effective intervention, which should be informative to policy makers and the public debate. We are the first to study such a broad cross-section of countries with different exchange rate regimes and at different stages of development, using data obtained on special request for this study from 33 central banks. The results suggest that intervention in currency markets is more common practice and effective than we would have expected, and that intervention

size and the communication strategy of central banks are important factors in enhancing effectiveness.

The paper proceeds as follows. Section 1 introduces the dataset. Section 2 provides stylized facts about FX intervention, and Section 3 shows our basic results on the effectiveness of actual intervention. Results on the effectiveness of communication (oral intervention) require data on press reports and are presented in Section 4. Section 5 discusses issues related to the identification of actual intervention, and Section 6 concludes.

1 Data

Actual intervention data are provided by 33 central banks issuing their own currencies in advanced, emerging and developing economies. This section provides details on data sources, sample countries, classification of exchange rate regimes, and representativeness of data.

Data sources. The dataset on actual, sterilized interventions comprises information from public sources and information received from bilateral data requests. To start with, we used all relevant data which have been previously published or used in other publications, such as Federal Reserve Economic Data (FRED) or central bank websites (see reference to sources in Table 1). We complemented the public data with data which we received from bilateral data requests. The countries which we approached were mainly from the members of the BIS Committee on the Global Financial System (CGFS). Further, we contacted those central banks which, according to the Annual Report on Exchange Arrangements and Restrictions published by the IMF (2010), collect daily intervention data. Overall, we approached 27 countries bilaterally of which 23 granted us access to their data. We obtained data on sterilized FX interventions by the respective institution at daily frequency with break-down by size and currency, for the period from 1995 to 2011.

[Table 1 about here.]

Sterilized interventions. Our analysis of FX interventions focuses only on sterilized interventions and our data request to central banks was specifically designed to get data about sterilized interventions. These are interventions which do not impact on the net foreign asset position of the public sector, which is mostly proxied by the position of the central bank. Basically, this means that the monetary base is not affected by these interventions. However, different central banks may have different notions of sterilized intervention or different

methods to sterilize, an issue to which we return later in the paper. Also, there may be other reasons for central banks to buy or sell foreign currency that are unrelated to their intentions to impact on FX rates, such as their foreign reserve management, in some cases their function as agent for central governments, and of course monetary policy operations. Therefore, we check later in the paper that our main results hold for the subsample of countries that publish their intervention data and that they hold when controlling for changes in monetary policy variables.

Interventions are almost exclusively conducted against a reference currency. This is usually the US dollar (USD) and, for European countries (and for the U.S.), the Euro (see Table 1). In a few cases we have recalculated interventions against another currency into the reference currency. Eliminating these cases from the sample does not change any result qualitatively.

Sample countries. The dataset includes Argentina, Australia, Azerbaijan, Bolivia, Canada, Chile, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, the European Monetary Union (EMU), Georgia, Hong Kong, Iceland, Israel, Japan, Kenya, Kyrgyzstan, Mexico, Moldova, New Zealand, Norway, Peru, Poland, Slovakia, South Africa, Sweden, Switzerland, Turkey, United Kingdom, United States and Venezuela. No single one of these countries or particular periods is driving our results (see Internet Appendix I.1 and I.2). For nine countries the data cover the full period of 17 years from January 1995 to December 2011. For another nine countries we have at least 15 years, and for the remaining 15 countries data was supplied for at least ten years, with the exception of Switzerland with seven years (see details in Table 1). The sample covers advanced, emerging and developing countries. Specifically, following the IMF World Economic Outlook definitions (IMF 2014), the sample covers 83 percent of advanced countries (30/36 countries, i.e. 13 currencies plus the Euro, which represents 17 countries during our sample) and 40 percent of emerging economies (10/25, plus nine poorer developing countries such as Bolivia). The trading days covered by intervention data are split roughly in half among these groups (46.2 percent to 53.8 percent, respectively).

Exchange rate regimes. In order to classify countries into exchange rate regimes we use data on de facto (and not de jure) exchange rate arrangements by Reinhart and Rogoff (2004). Fortunately, most of our countries fall into just three (out of six) coarse categories, which makes it straightforward to explicitly consider these three exchange rate regimes in the main analyses. However, there are not enough observations to analyze these regimes in separate sub-samples. In most countries, i.e. 22 countries in our sample, the currency regime did not

change over the observed period. The 11 exceptions are Argentina, Canada, the Czech Republic, Denmark, Georgia, Iceland, Kyrgyzstan, Moldova, Switzerland, Turkey and Venezuela, which reported interventions under more than one regime type.

The most populated regime in our sample is group "2" of Reinhart-Rogoff's "coarse" currency regime classification, which includes pre-announced crawling peg, pre-announced crawling band that is narrower than or equal to $+/-2$ percent, de facto crawling peg, and de facto crawling band that is narrower than or equal to $+/-2$ percent: we name this regime "narrow band". Group "4" covers countries with "freely floating" exchange rates and group "3" comprises countries whose exchange rate regimes are in between the other two; we call this group "broad band"[2]. Whereas group "4" is dominated by advanced economies, group "2" is dominated by emerging and developing economies; group "3" is mixed in this respect. Beyond these three groups of regimes there are three others, coded "1", "5" and "6" in the Reinhart-Rogoff classification which we do not analyze separately because they are rather special cases (definitions in Table 1), and because we only have few observations so that we cannot analyze these groups while ensuring anonymity of countries.

Representativeness. The sample of countries cannot be perfectly representative, because it is based on the willingness of central banks to provide data. In this respect, one could imagine that central banks conducting many secret interventions may not want to contribute to our study. However, we include a large number of interventions not being noticed in the press, many of which may be intentionally secret. Thus we can analyze the effects of many secret interventions in our study. Considering also the realized high response rate among central banks, our data are unlikely to be distorted by some form of self-selection bias of the respondent central banks.

Minimum intervention size. Some of the interventions in our data are very small, too small to be meaningful, even though they belong to those operations that central banks themselves classify as interventions (which is the criterion in our data collection exercise). In fact, most of these tiny transactions may be motivated by market making activity. This leads to a trade-off between relevance (of considering larger interventions) vs. completeness (considering all cases). In order to mitigate this issue, we recode the intervention volumes for a total of 469 intervention days with intervention volumes smaller than 0.00001 percent of a country's GDP as zero, which corresponds to less than 0.001 percent of daily

[2]These regimes include de facto crawling bands narrower than or equal to ± 5 percent, noncrawling band that is narrower of up to ± 2 percent and managed floating (Reinhart and Rogoff, 2004).

traded volumes even for little traded currencies (see Table 1). For a country of median size the chosen cutoff amounts to about 16,000 USD and average recoded interventions are well below 5,000 USD. The largest single value of a neglected intervention is 350,000 USD per day. These intervention days will henceforth be treated as days without intervention.[3]

2 Stylized facts about interventions

The broad coverage of countries in our sample allows us to identify some basic facts about FX interventions. These stylized facts refer to five dimensions, i.e. the incidence of interventions, their direction (purchase or sale), their size, their sequence, and characteristics of intervention days. We are also able to compare intervention behavior across three major exchange rate regimes, i.e. free floaters, broad bands and narrow bands.

Incidence. FX interventions are remarkably common. All of the central banks we received data from intervened at some point between the beginning of 1995 and mid-2011, and a total of 113,844 trading days are covered in this period by these central banks. On average, actual activity was reported by central banks on 19.1 percent of trading days (see Table 2). Activity within floating and broad band regimes is observed on about 8.7 percent of days, whereas within narrow band regimes central banks are active on about 34 percent of trading days. Figure 1 plots the share of central banks purchasing or selling FX on a given day during the sample period.

[Table 2 about here.]

Direction. On 76.1 percent of the intervention days we observe net purchases of foreign currency and on the remaining days foreign currency is sold on balance. While the share of purchases is expected to exceed 50 percent in a growing world, 76 percent seems to be beyond this expectation. Moreover, this result is surprising given the experiences from the Bretton Woods system and the many FX crises thereafter, where typically the exchange rate was defended by selling foreign currency (e.g. Eichengreen, 2008). By contrast, we find in our recent sample that the large majority of interventions are purchases of foreign currencies (see also Levy-Yeyati et al., 2013). This indicates a potential asymmetry in the objectives of the central bank, consistent presumably with a desire to support exports. Interestingly, there is not much of a difference across exchange rate regimes in this respect.

[3]The decrease in intervention days implied by this choice is driven by three countries which cover about three quarters of these interventions. However, we show in Internet Appendix I.3 that the reduced sample does not lead to qualitatively different results.

These aggregate statistics hide the fact that not all countries both buy and sell foreign currency. Among the 33 countries covered, eight countries never purchased foreign currency in the sample period, and eight others never sold foreign currency. This indicates substantial heterogeneity across countries and their policy objectives.

Size. The size of FX interventions, i.e. the daily net transaction volume, is on average 44.3 million USD, with higher volumes in free floating regimes. This pattern is related to the size of the respective economies as the share of advanced economies is highest in free floating regimes. For example, on average during the sample, the larger advanced economies' central banks purchase (sell) an equivalent of USD 122.1 million (102.9) compared to USD 30.1 million (31.5) in emerging and developing countries.[4]

Thus it is advisable to also use relative intervention volumes. Table 2 shows that in GDP terms the average size of interventions in broad bands (0.03 percent) is between those in floating regimes (0.02 percent) and narrow bands (0.05 percent). However, floating regimes – mainly related to advanced economies – are not only characterized by larger economies but also by much larger financial markets. Thus, if we relate intervention size to the respective daily FX trading volume, relative intervention size in floating regimes is even smaller compared to the other regimes.[5]

Sequence. Typically, FX interventions take place in a repeated fashion. In the case of FX buying, 68.6 percent of intervention days are preceded by an intervention in the same direction from the same central bank on the day before (86.9 percent during the three days before). In the case of foreign currency sales, these shares are somewhat lower but still substantial (47.2 percent and 72.8 percent). Intervention days are thus typically part of a longer intervention period, which complicates the analysis of their effects. In line with other papers (e.g. Fratzscher, 2008), we apply a ten day gap between days with interventions to define a new episode (see also Internet Appendix I.4 and I.5). This reasonably long gap between episodes makes it more plausible that episodes constitute separate events.

Table 2 reports the total number of episodes and their average length. According to our definition, the average length of an episode is 6.1 and 2.8 days for buying

[4]We use the exchange rate of the local currency with the USD or Euro to calculate the volume of the respective intervention in the foreign currency the country intervenes against. For countries targeting the Euro we then use the daily Euro-USD exchange rate to calculate the equivalent USD volume.

[5]Trading volume data are taken from the BIS triennial survey and interpolated linearly to yield values for the time between the survey years. Azerbaijan, Bolivia, Costa Rica, Croatia, Georgia, Iceland, Kenya, Moldova, and Venezuela are not included in BIS survey data and thus missing from statistics that feature traded FX volumes.

and selling FX, respectively. The longest spell is, on average across countries, 55.7 trading days for FX purchases and 14.5 for FX sales. However, these averages mask that the longest period of activity recorded in the sample was 345 trading days, i.e. almost 1.5 calendar years.

Further intervention characteristics. We find that central banks are typically leaning against the wind, i.e. against the trend of the ten trading days before the start of the intervention, in 66.5 percent of cases. Interventions go towards the fundamental exchange rate in 48.0 percent of cases, where we simply use a three-year moving average to approximate the fundamental value of a currency.[6] Alternatively we also use the IMF's Purchasing Power Parity (PPP) exchange rates as proxy for the fundamental value, leading to a share of interventions towards the fundamental of 51.4 percent. Finally, we observe interventions during periods of turbulence, defined as episodes when the VIX is more than two standard deviations above its median.[7] In turbulent times, central banks are active on 22.5 percent of days, slightly more than in tranquil times. This difference is mostly driven by narrow band regimes and translates into longer intervention episodes rather than frequently changing intervention directions, which would constitute new episodes. In the regressions below, we will also approximate the effect of volatility by including each country's exchange rate volatility on the first day of the intervention episode relative to the country's maximum during the sample. This variable is thus scaled between 0 and 1.

Summary. Considering all countries: FX interventions occur often (19.1 percent of trading days); they are mainly purchases of the foreign currency (in 76.1 percent of cases); the average transaction is about 44 million USD per day; interventions do not occur as single events but in sequences, and they occur most often in countries following a narrow band regime, which is mainly chosen by emerging and developing economies.

[6] Admittedly, this is a rudimentary measure of fundamental value and it is well documented that measuring a currency's fair value is a very complex task (e.g. Menkhoff et al., 2017, and the references therein). However, our simple measure has the advantage to capture mean reversion in a simple way that does not require macroeconomic data nor any econometric model while being easy to replicate. Results are not affected by using five-year or eight-year moving averages, as we show later.

[7] The VIX is a widely used measure of expected short-term volatility of the S&P500 and it is based on the implied stock market volatility embedded in S&P500 stock options. It is often used by academics and practitioners to capture global risk aversion in financial markets.

3 Effectiveness of actual interventions

3.A Effectiveness of intervention operations

The effectiveness of FX intervention policy is highly controversial and debated (see, e.g., BIS, 2013a). There are three main lines of arguments that are put forward by skeptics: the difficulty of changing the market outcome of the exchange rate; the small size of central banks in increasingly large currency markets; and the limited information in interventions as a policy signal.

Influencing market outcomes. FX interventions often run counter to prevailing market forces. Thus, interventions should bring new information to the markets, i.e. changing the market's information set, in order to be effective. This is no easy task because interventions take place when markets deliver outcomes which policy makers do not like. In this sense interventions have to overcome high hurdles, at least in market environments such as floating exchange rate regimes.

Huge FX markets. A second source of skepticism is rooted in the limited size of interventions in today's very large and liquid FX markets. FX transactions have substantially increased over the past decades, thus reducing the relative importance of central bank actions over the same time period. Taking, for example, FX reserves of all countries together the resulting amount of more than 4 trillion US dollars is in the same order of magnitude as daily transactions in FX markets (see BIS, 2013b). Moreover, the distribution of reserves is concentrated in a few countries. For example, China alone holds almost half of them and Japan contributes another 15 percent.[8]

Limited policy signals. The third line of argument against intervention is related to the ability of a central bank to signal its policy stance and provide new information to financial markets (Mussa, 1981; Vitale, 2003). The skeptical view here argues that it is in the interest of policy makers to signal intentions such as the likely course of future monetary policy to the markets anyway, and it is not clear what the additional contribution of FX intervention could be.

3.B Measures of effectiveness

The effectiveness of any FX intervention should be assessed with respect to the intervention objectives. These objectives vary according to preferences and circumstances, and true objectives will be in many cases impossible to find out.

[8] On a more optimistic note, however, Fatum (2015) argues that, for the Japanese foreign currency interventions at the zero lower bound, intervention was effective. However, these interventions were evidently not fully sterilized as bank deposits at the Bank of Japan increased at the same time.

In line with the literature, we proceed more modestly and aim to approximate intervention objectives. Regardless of the effectiveness measure, we analyze intervention episodes in order to account for the fact that interventions tend to last longer than one day. The last day of an intervention event is defined as a day which is either followed by no similar intervention in the next 10 trading days or by an intervention in the opposite direction.

The aim of affecting the exchange rate through intervention is often defined by various empirical measures of effectiveness which we apply below (see Humpage, 1999; Fatum and Hutchison, 2003; Fratzscher, 2008, 2009). In the following we present the three criteria that are meant to capture the heterogeneity of the main exchange rate regimes' objectives.

First, using the event criterion, we test whether the exchange rate moves in the intended direction during the intervention episode. If the central bank buys (sells) foreign currency, we code the event criterion "1" if – defining the exchange rate as the foreign currency price per one unit of domestic currency – the exchange rate decreases (increases) during that episode. This criterion clearly captures the intervention objective of affecting the level of the exchange rate and thus fits well central banks' behavior in free floating regimes. Of course, moving the exchange rate in the intended direction is also desirable for central banks that implement band regimes but for them other objectives are typically more important. Second, an intervention objective followed by central banks regardless of their exchange rate regime is to limit exchange rate volatility (Adler and Tovar, 2011; Menkhoff, 2013; Daude et al., 2014; Cavallino, 2017).[9] This objective can be captured using the smoothing criterion, which is coded "1" if the exchange rate change during and for five trading days after the intervention is smaller than during the five trading days leading up to the intervention; decreasing the five days period makes this criterion less demanding. In line with other studies, we choose a post-intervention window of five days (see Fatum and Hutchison, 2003; Fratzscher, 2008). In order to make the criterion meaningful we define it only for interventions against the trend of the previous five trading days. Third, we complement the above standard criteria by also considering what we call the stabilization criterion. This states that the exchange rate is kept

[9]This has been a major objective for many central banks (BIS, 2005), with about two thirds of polled central banks calling "limiting exchange rate volatility" an immediate objective of intervention between 2005 and 2012 (Mohanty and Berger, 2013). An example is Mexico where the central bank posts on its website about the IMF's Staff Report for the 2017 Article IV Consultation: "There was agreement that exchange rate flexibility should remain the key shock absorber. A flexible adjustment of the exchange rate is indispensable to restore equilibrium in response to shocks. FX interventions in the spot market or through non-deliverable forwards (NDFs) settled in local currency are better suited to respond to disorderly market conditions associated with excessive volatility. Staff and the authorities agreed that a mix of exchange rate adjustment and intervention [...] could be used to address the materialization of risks" (IMF, 2017).

within a narrow band of two percentage points during the whole intervention event and the two weeks after its end. The definition of a two percentage point range fits the definition of narrow band regimes by Reinhart and Rogoff (2004).

Central banks follow a set of potential objectives; in their survey of central banks Mohanty and Berger (2013) aggregate these objectives into five groups, for example.[10] We use the above success criteria to capture these different objectives, although this does not mean that these objectives are unrelated to each other. In fact, they may well be mutually consistent in certain circumstances. For example, if a central bank is leaning against the wind to reverse an appreciation trend in the exchange rate, effective intervention will imply success both under the event criterion (as the exchange rate changes direction) and the smoothing criterion (as the trend in the exchange rate is reversed, thereby reducing its volatility). However, if the intervention operation does not change the direction of the exchange rate but simply reduces the appreciation trend, this would imply lack of success under the event criterion (direction does not change) but success under the smoothing criterion (as the exchange rate trend becomes less strong). More generally, the three different criteria capture different aspects of intervention effectiveness, and ex ante they are not perfectly correlated. In fact, the empirical relationships between the three success criteria in terms of pairwise correlations, reported in Table 3, suggest that the correlations across success criteria are far from perfect, indicating that these criteria capture different objectives and that success under one criterion does not necessarily require or imply success under the others.

[Table 3 about here.]

3.C Unconditional outcomes of actual interventions

Having defined effectiveness criteria we first look at unconditional outcomes of interventions for each of the three exchange rate regimes considered, i.e. distinguishing freely floating exchange rates, broad bands and narrow bands. For each of these regimes we report results for the two most relevant criteria.[11]

[10] Cavallino (2017) also shows that, in the context of a general New Keynesian equilibrium model with incomplete markets, under free float and some degree of nominal rigidities optimal exchange rate intervention implies that the central bank wishes both to smooth exchange rates to reduce volatility and to affect the exchange rate level, as distinct objectives. This would imply that both the event criterion and the smoothing criterion are meaningful when evaluating effectiveness of a central bank operating under free float.

[11] However, we also report averages in the pooled sample across all regimes in Table A1 in the Internet Appendix. This table also includes "placebo" success rates for the counterfactual, i.e. the percentage of cases in the pooled sample of non-intervention periods where exchange rates behave in line with the effectiveness measures. Furthermore, average success rates when weighting each country equally as well as average success rates in turbulent times are reported.

Free floaters (columns 1 and 2 in Table 4) have some success in influencing the direction of exchange rates. In the short term more than 60 percent of FX interventions are successful at moving the exchange rate in the intended direction; this is significantly better than random as the placebo rates show that success is around 48 percent in our data.[12] Smoothing is successful in 88 percent of cases.

[Table 4 about here.]

Countries pursuing narrow band regimes (columns 5 and 6) on the other hand are mainly interested in the stabilization criterion. They are highly effective at pursuing it, managing to keep the exchange rate within the narrow band in about 84 percent of intervention episodes. Of course, the benchmark of success – i.e. exchange rates within the narrow band – is higher than 50 percent for narrow band regimes; it is in fact 77 percent. These countries also succeed regarding the smoothing criterion, as do the broad band regimes (columns 3 and 4) many of which do not aim to stabilize the exchange rate within a narrow band and often target broader bands between 2 percent and 5 percent (Reinhart and Rogoff, 2004). It is thus not surprising that many of the latter do succeed in stabilizing their exchange rate according to our 2 percent criterion.[13]

3.D Determinants of effectiveness in actual interventions

Next, we analyze which intervention characteristics are associated with higher probability of success. To account for heterogeneity between regimes, we always include currency regime-specific intercepts (which are easier to interpret than classical fixed effects). However, due to the small number of countries (observations) in the floating regime, we cannot usefully run regressions for each regime separately without undermining the confidential nature of our data. In the baseline regression we allow for other variables to capture four further considerations.

The first consideration is that "larger" interventions should improve the probability of success independent of success criterion and exchange rate regimes

[12] Placebo rates are calculated by creating intervention days in random directions on non-intervention days and calculating the success criteria for placebo intervention episodes with median country-specific intervention lengths. The simple averages above therefore do not assume any selection mechanism for intervention along the lines of a reaction function that takes into account market circumstances. Such extended analyses are presented later in the paper. Finally, note that we report p-values in Table 4 to formally document that the success rate in each column is statistically significantly different from placebo rates; this is always the case except for column 4, corroborating the interpretation that follows.

[13] In Table A2 we show that stylized results shown in the next section remain similar when using alternative bandwidth ranging from 2 percent to 5 percent and are robust to restricting the subsample to narrow and broad band regimes, only.

(Fatum and Yamamoto, 2014; indirectly in Dominguez et al., 2013). To capture this we control for the average intervention size during an event as a share of the GDP of the intervening country. Second, we test whether interventions occurring in line with a prior trend are more likely to succeed in moving the exchange rate. This could be expected because intervention does not "lean against the wind" of market forces. Third, we expect that intervention is more effective if it occurs in line with fundamentals. Such an intervention motivation is often relevant in free floating regimes, so that it should align with the event criterion. However, band regimes aim more at keeping the exchange rate stable than keeping it closely in line with a fundamental rate so that we do not expect this intervention characteristic to strongly support the smoothing or even less the stabilization criterion.[14] Fourth, we analyze whether volatility has any influence on intervention effectiveness. Higher volatility is expected to be unrelated to the event criterion but a clear characteristic to stimulate smoothing interventions; if these succeed (as the unconditional results indicate) the expected coefficient sign is positive. By contrast, volatility makes stabilization efforts clearly difficult so that it is unclear whether the relation between volatility and stabilization success is indeed positive. As the volatility over a period is not easily comparable across countries, for example because of regime differences and market size, we consider the degree of local volatility relative to the country's maximum.[15] The role of other covariates, such as the length of an intervention episode or the global market environment, is tested in the Appendix (see Table A3).

Results using OLS regressions are shown in Table 5. Logistic regressions yield qualitatively identical results, as we show in the Internet Appendix I.10. However, OLS regressions allow adding up of the coefficients of the various intervention conditions. The left-hand-side variable is the respective effectiveness measure which is coded as a binary variable indicating success. The characteristics of intervention episodes are included in the vector X_i. We then estimate the success criterion c_{ir} in intervention episode i in regime r as

$$c_{ir} = \theta_r + \gamma X_i + \epsilon_{ir},$$

where θ_r denotes currency regime fixed effects that are introduced as regime-specific intercepts and ϵ_{ir} is the error term.

[14]The fundamental exchange rate is defined as the three-year moving average of the exchange rate. Results are qualitatively robust to various modifications, including those relying on PPP exchange rates, as shown in Internet Appendix robustness points I.6, I.7 and I.8.

[15]This is measured as the quarterly exchange rate volatility on the first day of the intervention episode as a share of the country's maximum during the sample period. Using alternative measures of volatility does not change results qualitatively, see Internet Appendix I.9.

[Table 5 about here.]

Event criterion. We provide evidence on the effectiveness of intervention in Table 5. Looking at the event criterion, which is key for free floating regimes, we see that the pure purchase or sale of FX has a probability of success of 0.53 in free floating regimes. This baseline success rate is well above the placebo success rate in Table 4 for free floaters but not for other regimes, which is expected given that this criterion is mainly relevant for intervention of free floaters.[16]

In fact, the likelihood of intervention success can increase further depending on the characteristics of an intervention. Larger interventions are significantly more likely to move the exchange rate in the intended direction; large intervention sizes of, for example, 0.4 percent of a country's GDP increase success probability by about 13.2 percentage points. Also, interventions that are in line with markets, i.e. with the trend in the two weeks before the intervention, are significantly more successful. Intervening with a trend is associated with a 9.9 percentage point increase in the success rate. The probability that interventions towards the fundamental value succeed increases with the distance between the exchange rate and its fundamental value. For the median misalignment of the exchange rate from its fundamental value, the increase in the success rate is 3.5 percentage points. Accordingly, the increase is much higher for severely misaligned currencies. We conclude that under the event criterion interventions in free floating regimes are mostly effective, and effectiveness increases under specific circumstances. For example, adding up coefficients as discussed above, the success rate as measured by the event criterion increases to about 80 percent (53.2+ 13.2 + 9.9 + 3.5 = 80.0). However, under the event criterion effectiveness is weaker for other exchange rate regimes, as expected.[17]

Smoothing criterion. Interventions are quite effective at smoothing exchange rates. This holds for all exchange rate regimes. In essence, under any regime the central bank is successful in decreasing the pace of an appreciation or depreciation. Due to success rates of more than 70 percent there is not much scope for further improving performance. However, we find that smoothing is more likely to be successful in highly volatile phases.

[16] Specifically, compared to the freely floating currency regime, the regime-specific intercepts show that narrow and also broad band regimes are much less successful according to the event criterion which makes sense given their targets. For an overview across all success criteria and regime types, see Table A4 in the Internet Appendix.

[17] In an additional analysis we look at the effect of size on intervention success by calculating elasticities. The sample is confined to free floating regimes and days without an intervention on the previous day, in order to focus on the more relevant cases. The relation between intervention volume (as percent of GDP) and the percentage change of the exchange rate needs to be estimated separately for purchases and sales of foreign currency because these will move the exchange rate in opposite directions if effective. We find that the coefficient for sales is much larger than for purchases, and that they are both strongly statistically significant (see Table A5 in the Internet Appendix and further discussion in Internet Appendix I.11).

Stabilization criterion. The stabilization criterion is of particular relevance for narrow band regimes and this is confirmed by the results in Table 5. Interventions in volatile times (according to the local volatility measure) are less likely to restrict the exchange rate to the narrow two percent band which is specified as a success. As interventions towards the fundamental are more likely to move the exchange rate, interventions occurring when exchange rates are further away from fundamental value are associated with a decrease of the likelihood of a stable exchange rate in the subsequent days. Most remarkable seems to be the very high regime-specific intercept for the narrow band regime (0.949), indicating that intervention works very well, while high local volatility is the major hampering factor. For broad band regimes, the intercept is only one third smaller than for narrow band regimes, and for free floaters the estimate is less than half. In short, the pecking order for success under the stabilization criterion confirms the prior that this criterion is primarily relevant for exchange rate regimes with little flexibility of the currency, and increasingly less relevant as one moves towards more flexible exchange rate regimes.

Discussion. Overall, we see that intervention effectiveness is systematically determined by several plausible characteristics: If in floating regimes the main intervention objective is moving exchange rates, it is important to consider several determinants of success, such as intervening with large volumes. According to our evidence, then success can occur in 80 percent of cases (the interpretation is explained in detail in Internet Appendix I.12). This success is somewhat lower at 70 percent in broad band regimes while it is not there for narrow bands. Interestingly, smoothing due to interventions seems to work quite well, especially in more volatile periods and regardless of the FX regime. Finally, tight exchange rate stabilization works best in narrow band regimes but much less in the other regimes and is only endangered by very high exchange rate volatility.

4 Effectiveness of central bank communication to intervention success

In this section we consider the effect of authorities' communication on exchange rates. It is well known that communication can support monetary policy (Blinder et al., 2008) or non-sterilized FX intervention (Burkhard and Fischer, 2009). Fratzscher (2008) also provides evidence on effectiveness of oral intervention, which we extend here. Thus, in the next section we introduce the underlying press report data for analyzing the role of authorities' communication. Then, we provide our baseline results on oral intervention as well as further extensions.

Data about authorities' communication. In order to test the effect of communication we analyze press reports covered by the database Factiva. We use a standardized working procedure where news reports for each currency are searched including keywords such as "FX" and "intervention"; we also allow for different spelling and abbreviations. Before coding the resulting news reports we defined the criteria for events of interest. All news reports were then coded using double entry. In doing so, we check whether officials (mainly from the central bank) have talked about intervention, i.e. whether an oral intervention in addition to an actual intervention takes place. We define oral interventions as statements by the central bank or minister of finance in favor or against a currency. This can mean comments about the future likelihood of intervention or the currency is talked into a particular direction. The announcement is tied to the specific day it occurred but the intention can be general and forward looking. In principle, an oral intervention could take place without an actual intervention, providing the interesting case of "isolated" oral intervention. However, there are just about 20 such cases in our sample. Thus, we cannot reliably work with this extremely small sample.

Authorities very often talk to the market about interventions or currencies more generally, and thus oral interventions are frequent and occur in 51.9 percent of all intervention episodes. As expected, this share is much higher in free floating regimes (with 96.8 percent) and broad band regimes (99.6 percent) than in narrow band regimes (30.9 percent). As we are only using actual interventions in these estimations, the oral interventions we analyze here always go hand in hand with actual activity. In this sense oral intervention is intended to reinforce actual intervention. The multivariate regression controls for some circumstances of intervention such as previous exchange rate volatility. Still, it cannot be ruled out that central banks decide to intervene orally when they consider the market environment to require extra guidance. This applies especially to the event criterion which is key for free floaters who need to explain to financial markets why they intervene.

Oral intervention could furthermore have greater potential according to the smoothing and stabilization criterion in turbulent times, when authorities may provide useful guidance to markets. Evidence for this case is provided, for example, by Égert and Kočenda (2014) for three Eastern European exchange rates and by Born et al. (2014) for the effect of central bankers' speeches. The theoretical case for intervention at times of higher risk aversion is also made in the model of Gabaix and Maggiori (2015). Therefore, in addition to a dummy variable for oral interventions we consider the potential importance of communication

in turbulent times by introducing an interaction term between turbulent times and oral intervention.

Empirical results. Turning to empirical results, we find that oral interventions not only increase the odds of moving the exchange rate when only including a dummy for oral interventions (Table A6); they also substantially increase the success rate of interventions in turbulent times, according to the event and smoothing criterion (Table 6).[18] This seems to suggest that central bankers' communication is taken particularly seriously by markets in volatile phases. However, regarding the stabilization criterion there is no effect of oral interventions. Additional analyses for narrow bands indicate that the positive effect of oral intervention comes from more flexible regimes.

[Table 6 about here.]

Pre-announcement of regime. As we have seen that oral intervention can be a way to inform markets and thus to increase effectiveness of actual interventions, we study differences between cases where authorities do and do not make an announcement regarding their strategy. While typically using the coarse grid classification, Reinhart and Rogoff (2004) also offer a finer grid, which distinguishes between regimes that are pre-announced and not-pre-announced within the coarse categories. We construct a dummy variable which takes the value 1 if authorities have pre-announced their regime. This is then interacted with oral interventions in the specification known from Table 6.[19] The estimates are reported in Table A7 and show that central banks that do not pre-announce their regime can use oral interventions to significantly increase their likelihood of successfully moving the exchange rate. In this case, a small and statistically significant effect is also found for the stabilization criterion. Hence, oral interventions seem to be particularly effective if the market is unsure about the exact policy of the central bank.

On channels of intervention. Overall, if there are benefits of explicit oral interventions, in particular during turbulent times, this has implications for the potential channels by which interventions may impact on exchange rates. The link to the signaling channel, the main channel by which oral communication can have any effect, is obvious. The portfolio balance effect may also be at work as larger intervention sizes have stronger impact in our data, which is consistent

[18] Adding interaction terms of oral intervention with other intervention characteristics such as size, leaning with the wind or intervention towards the fundamental (results available on request) does not affect the above mentioned positive significant interaction of oral intervention and intervention in turbulent times.

[19] To take account of the use of the finer grid, we use finer grid currency-regime fixed effects instead of the coarse grid effects that are generally used in this paper.

with the standard mechanism of portfolio balance models, whereby larger interventions induce larger changes in private sector portfolios and thereby larger changes in exchange rates and risk premia. However, as a note of caution, we are mindful that our reduced-form regressions do not allow us to precisely disentangle the different channels of FX intervention, which in our view requires a more structural estimation approach than our event study methodology allows.

5 On identification of FX interventions

The empirical analysis of FX intervention is often plagued by the problem of clearly isolating the causal effect of this policy instrument. We address two concerns that arise in this context. First, the use of FX interventions is often the result of specific circumstances in FX markets, potentially resulting in endogeneity (Section 5.A). Second, FX intervention is a policy measure which may be used in combination with monetary policy instruments (Section 5.B).

5.A On the endogeneity of FX interventions

The issue of isolating a causal effect of FX interventions against the potential influence from specific circumstances in the markets has been addressed in the literature using a variety of methods, which we fully discuss in the Internet Appendix II. Here we simply present a qualitative discussion on the role of endogeneity in empirical work and apply a matching approach.

Qualitative reasoning. Let us start from noting the general point that FX interventions do not occur randomly. Rather, intervention decisions are typically motivated by unwanted market developments, implying that the circumstances for interventions are disadvantageous; this generates bias against intervention success. This effect may be reduced, however, by the experience of the central banks which select periods in which they see a good chance to realize their ambitions. An example in this direction is knowledge about intra-daily market circumstances which can increase intervention effectiveness (see Dominguez, 2003). This kind of endogeneity in favor of success, however, is rooted in the authorities' ability and thus represents a kind of missing determinant in our framework. More generally, omitted variables related to other macro policy actions that can impact on exchange rates, most obviously monetary policy actions, can generate bias that over-estimates the impact of intervention. Furthermore, independent of the timing, also the design of the intervention by the central bank may be co-determined by market circumstances, requiring some caution in interpreting the effects that are at the discretion of the central bank, namely intervention size and whether actual intervention is paired with oral intervention. In short,

there are various aspects making the estimation of the effectiveness of FX intervention a difficult task, and various methods that can be used to investigate the importance of this issue, to which we now turn.

A matching approach. This approach involves selecting suitable counterfactuals by a matching mechanism to account for market circumstances (see Fatum and Hutchison, 2010). We build on this idea to match actual intervention events and placebo events, and yield a treatment and a control group. Actual and placebo success criteria are then used to create a joint outcome variable, taking the actual success rate for actual events and the placebo success rate for placebo events. We then use a nearest neighbor matching algorithm to match within country each actual episode with the most similar placebo episode using the characteristics that were most important according to Table A8 (this table reports results on a central bank reaction function approach which is described in detail in the Internet Appendix II). These are the lagged absolute FX misalignment and the lagged absolute change in the exchange rate leading up to the day before the first (actual/placebo) intervention day. Furthermore we account for intervention length.[20] In Table 7 we report results for the treatment effect when basically reproducing Table 4 above. The results are consistent with those in Table 4, but the size of coefficients is larger, indicating that our earlier results may underestimate the true intervention effectiveness.[21]

[Table 7 about here.]

5.B FX interventions and monetary policy

A natural concern about any analysis of FX interventions is whether interventions are accompanied by further policy measures, in particular by monetary policy, and thus the measured intervention effect may be illusive. A straightforward way to check this concern is by analyzing whether interest rates change at times of intervention. It could occur that the sale of foreign currency, in order to stabilize the domestic currency, is accompanied by an increase of the short-term domestic interest rate. We calculate the day-on-day change in the domestic interest rate (Δi) using money market rates for countries for which daily data are available. The results do not indicate any systematic change in interest rates on days with interventions (Table A10 in the Internet Appendix). Furthermore, we test whether intervention effectiveness is systematically associated with those unrelated changes in interest rates (Table A11). As these regressions use a

[20] Matching is possible for most episodes. In a few cases matching fails, typically because there is no close enough equivalent placebo intervention regarding the FX misalignment. This requires some trimming of the data.

[21] Alternative matching estimates using different misalignment horizons are provided in Table A9.

smaller sample than the one of our main regressions due to data availability, we repeat the examinations underlying our main Table 5 for this subset in Table A12, which yields no systematic differences relative to the main sample. Thus, the results indicate that interventions and interest rate policy are rather independent, which confirms that the central banks in our sample provided us with the data on sterilized intervention as per our request.[22]

6 Conclusion

FX intervention is a controversial policy tool as much literature has not detected systematic evidence that intervention moves exchange rates in the intended way. This result is often supported by two lines of argument. First, the FX market is the largest financial market in the world by volume (BIS, 2013b) and over time central banks have become increasingly smaller players in terms of trading volume. Second, FX markets incorporate fundamental news quickly (Andersen et al., 2003), and in the long-run they are anchored to fundamentals (Mark and Sul, 2001; Engel et al., 2008), which raises the question of what central banks can convey beyond available knowledge. In contrast to this view, survey evidence suggests that central bankers around the world believe in the usefulness of FX intervention (e.g., Neely, 2008). Thus, is FX intervention effective?

Using confidential data on FX intervention, we make a general assessment of intervention effectiveness for 33 central banks. First, this broad set of central banks has intervened, on average across countries and time, 19 percent of our daily observations, which suggests that this policy tool is widely and commonly used. Indeed all central banks in the sample intervene over the period from 1995 to 2011, irrespective of their exchange rate regime. Second, we find clear evidence that FX intervention is an effective policy tool. To give an order of magnitude, interventions in our sample tend to be effective in about 80 percent of cases under some criteria. Of course, intervention effectiveness depends on circumstances. Considering the effectiveness in various exchange rate regimes, intervention stabilizes exchange rates in more than 80 percent of cases if one looks at narrow band regimes. Also, if the objective is to smooth exchange rates, intervention works quite well in all major regimes, including broad bands. It is when authorities intend to move the level of exchange rates by interventions in floating regimes where conditions are most important: the baseline success rate is around 60 percent but it can increase to 80 percent if the intervention size is very large and if it follows the trend rather than leaning against it. Moreover, in-

[22] Intervention could also be associated with changes in the monetary base if not fully sterilized. Running regressions at quarterly frequency we find that net intervention amounts are uncorrelated with changes in the monetary base as Table A13 in the Internet Appendix shows.

tervention is more effective if it is accompanied by oral intervention, especially in turbulent times.

Overall, given the difficulty of influencing financial markets and that our data are based on true intervention operations of central banks, the evidence reported in this paper indicates that authorities around the world master the art of FX intervention better than one might expect.

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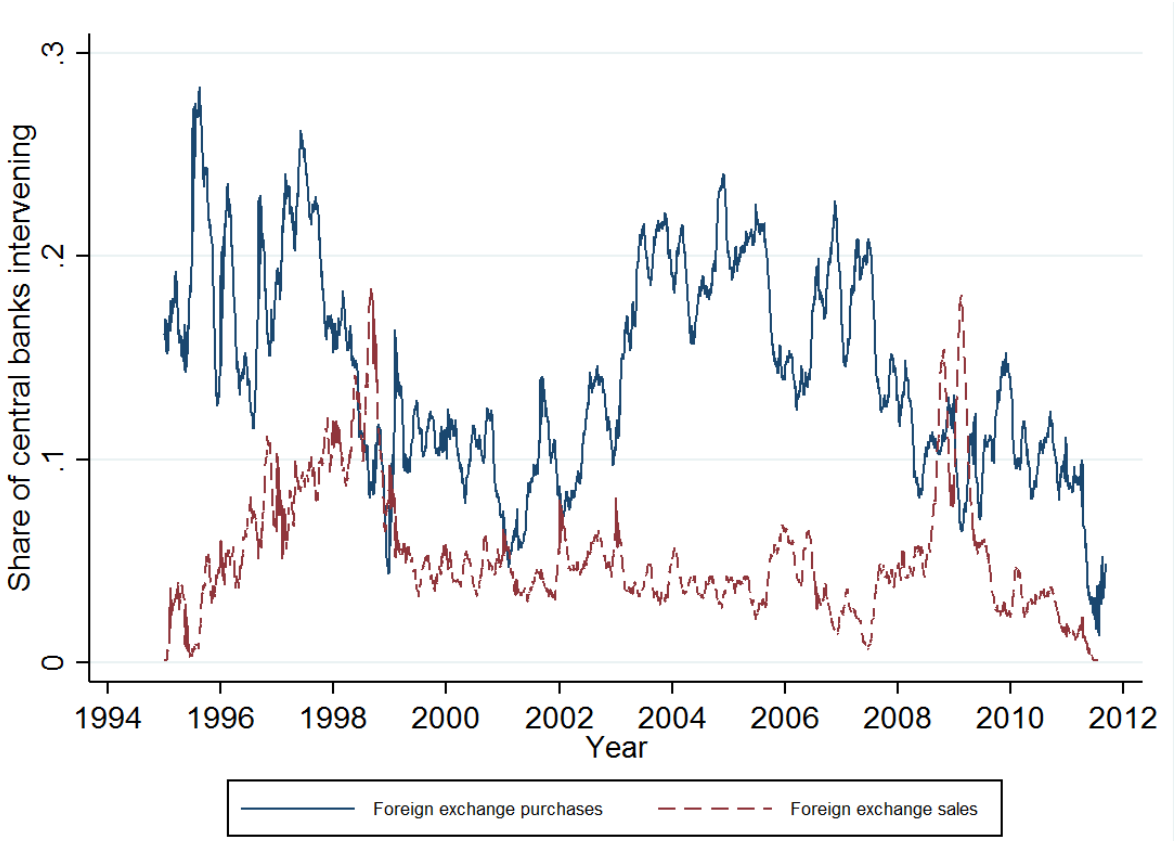

Notes: The graph reports intervention activity smoothed using a rolling moving average including 20 lagged and forward trading days each.
Source: Authors' calculations.

Figure 1: Daily shares of foreign exchange purchasing and selling central banks in the sample

Table 1: *Descriptive characteristics of covered countries*

Country	Datasource	Reference currency	First year of coverage	Last year of coverage	Average GDP in bn. USD in sample period	Average GDP per capita in PPP USD in sample period	Average traded FX volumes[a] in mill. USD/day in sample period	FX regimes[b]
Argentina	Public	USD	2003	2011	235	12761	964	2.6
Australia	Not public	USD	1998	2011	684	32910	45167	4
Azerbaijan	Not public	USD	2001	2011	24	6108		2
Bolivia	Not public	USD	2000	2011	12	3807		2
Canada	Not public	USD	1995	2011	952	32745	30636	2,3
Chile	Public	USD	2001	2011	129	13508	3416	3
Colombia	Not public	USD	1999	2011	158	7605	1385	3
Costa Rica	Not public	USD	1996	2011	21	9237		2
Croatia	Not public	EUR	1996	2011	38	14076		2
Czech Rep.	Not public	EUR	1995	2011	110	19322	949	2,3
Denmark	Not public	EUR	1995	2011	230	30819	3227	1,2
Georgia	Public	USD	2002	2009	6.9	3770		2,3
Hong Kong	Not public	USD	1998	2009	178	33966	34435	1
Iceland	Not public	USD	1995	2011	11	31177		2,3
Israel	Not public	USD	1995	2011	137	24257	2492	3
Japan	Public	USD	1995	2011	4534	28441	133987	4
Kenya	Not public	USD	1999	2011	20	1381		2
Kyrgyz Rep	Public	USD	1998	2011	2.8	1759		2,5
Mexico	Public	USD	1997	2011	769	12136	13303	3
Moldova	Not public	USD	1996	2011	2.9	2105		1,2,5
New Zealand	Not public	USD	1995	2010	86	22395	4186	3
Norway	Not public	EUR	1995	2011	253	43339	1504	3
Peru	Not public	USD	1995	2011	77	6230	461	2
Poland	Not public	EUR	1995	2010	267	12533	874	3
Slovakia	Not public	EUR	1999	2008	42	15164	166	2
South Africa	Not public	USD	1999	2010	169	7660	7536	4
Sweden	Not public	EUR	1995	2006	288	26782	2412	3
Switzerland	Public	USD	1995	2001	295	29516	17851	2,3
Turkey	Public	USD	2002	2011	510	11289	5268	4,5
UK	Public	EUR	1995	2011	1859	29020	36865	3
US	Public	EUR	1997	2011	11561	41377	170043	4
Venezuela	Not public	USD	1997	2011	161	10028		2,6
EMU	Not public	USD	1999	2011	9724	28813	47732	4

Notes: EUR indicates that reference currency was DEM before the introduction of the Euro. [a]: Source: BIS survey. Not available for all countries. [b]: According to Reinhart's and Rogoff's "coarse grid". The most rigid regimes are coded 1. Narrow bands (2) comprise preannounced crawling pegs, prennounced crawling bands that are narrower than or equal to ± 2 percent, de facto crawling pegs, de facto crawling bands that are narrower than or equal to ± 2 percent, as well as preannounced crawling bands that are wider than ± 2 percent. Broad bands (3) comprise de facto crawling bands that are narrower than or equal to ± 5 percent, noncrawling bands that are narrower than or equal to ± 2 percent and managed floats. Freely floating is coded 4. Freely falling is coded 5 and dual markets in which parallel market data is missing is coded 6.

Table 2: *Descriptive characteristics of interventions by regime type*

Indicator	Total	Free Floaters	Broad bands	Narrow Bands	Other
Number of country-regime observations[a]	43	6	14	17	6
Trading days covered	113,842	19,330	41,604	42,961	9,947
Share of days with FX intervention	0.191	0.073	0.093	0.336	0.207
Share of these with FX purchase	0.761	0.948	0.735	0.732	0.636
Share of these with FX sale	0.239	0.052	0.265	0.268	0.364
Average daily volume on intervention day in million USD	44.3	59.2	42.7	27.1	157.7
Average daily volume of FX purchases in million USD	44.4	52.7	45.8	24.9	190.6
Average daily volume of FX sales in million USD	44.1	177.1	34.2	33.3	100.2
Average daily intervention size as share of GDP	0.0005	0.0002	0.0003	0.0005	0.0010
Average daily intervention size as share of daily traded fx volume[b]	0.046	0.010	0.052	0.051	0.065
FX purchasing episodes[c]	2,388	70	551	1,491	276
FX sale episodes[c]	2,161	25	511	1,402	223
Average length of episode in days	4.5	9.2	3.5	4.8	4.4
Share of intervention episodes leaning with the wind	0.355	0.253	0.471	0.333	0.256
Share of intervention episodes towards the fundamental	0.480	0.400	0.488	0.482	0.466
Trading days covered in turbulent times	5,638	949	1,975	2,178	536
Share of days with FX intervention in turbulent times	0.225	0.027	0.092	0.435	0.207

Notes: [a]: Countries changing their regimes are counted more than once. No country returned to a previous regime after an interruption. Country-regime combinations are combined in "other", i.e. belong to other regime classifications such as pegs. [b]: Not available for all emerging markets, cf. Table 1. [c]: According to 10 day definition. Interventions leaning with the wind are defined as interventions that take the same direction as the previous two weeks' trend. Interventions towards the fundamental that aim into the direction of the three year moving average of the exchange rate. Turbulent times are defined as times when the CBOE VIX is 2 standard deviations above its median during the covered period.

Table 3: *Correlation between success criteria*

Success criterion	event	smoothing	stabilization
event	1.00		
smoothing	0.31	1.00	
stabilization	-0.08	0.05	1.00

Notes: The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks.

Table 4: *Unconditional success rates of intervention episodes by regime*

	(1)	(2)	(3)	(4)	(5)	(6)
Regime	Free Floater		Broad Band		Narrow Band	
Criterion	Event	Smooth	Smooth	Stabilize	Smooth	Stabilize
Intervention episodes	0.611	0.883	0.791	0.348	0.781	0.840
Placebo rates	0.481	0.401	0.396	0.495	0.342	0.768
P-value (H0: equal effectiveness)	0.012	0.000	0.000	0.000	0.000	0.000
P-value (H0: actual $\leq$ placebo)	0.006	0.000	0.000	1.000	0.000	0.000
Actual events	95	77	561	1,062	1,010	2,893

Notes: The (unmatched, cf. Table 7) placebo effectiveness is calculated based on all days that do not belong to an intervention episode. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The panels are separated according to the "coarse grid" by Reinhart and Rogoff (2004). Broad bands comprise pre announced crawling bands of at least ± 2 percent, de facto crawling bands of up to ± 5 percent, moving bands of up to ± 2 percent and managed floats. Narrow bands comprise more rigid arrangements. The p-values indicate tests with the H0 that actual intervention is equally likely to affect the success criteria as placebo intervention (top) and the one-sided hypothesis that actual intervention is more effective than placebo interventions.

Table 5: *Determinants of effectiveness of foreign exchange intervention*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.532***	0.798***	0.435***
	(0.053)	(0.043)	(0.044)
Broad Band	0.414***	0.712***	0.609***
	(0.024)	(0.028)	(0.024)
Narrow Band	0.213***	0.745***	0.949***
	(0.012)	(0.018)	(0.009)
Other Regime	0.133***	0.835***	1.004***
	(0.021)	(0.031)	(0.013)
Intervention characteristics			
Average daily intervention size in percent of GDP	0.330***	0.115	0.104
	(0.104)	(0.077)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.099***	-0.065**	0.011
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.004***	0.001	-0.004***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	0.004	0.215***	-0.597***
	(0.041)	(0.050)	(0.039)
Observations	4,549	1,787	4,549
Adj. R-squared	0.373	0.800	0.810

Notes: The table reports estimates from our event study approach. The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification. Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively.

Table 6: *Effectiveness and oral intervention by central banks*

Criterion	(1) Event	(2) Smoothing	(3) Stabilization
Regime-specific intercepts			
Free Floater	0.462***	0.873***	0.477***
	(0.056)	(0.048)	(0.046)
Broad Band	0.340***	0.790***	0.655***
	(0.029)	(0.036)	(0.027)
Narrow Band	0.192***	0.791***	0.964***
	(0.013)	(0.021)	(0.010)
Other Regime	0.081***	0.886***	1.038***
	(0.025)	(0.032)	(0.016)
Intervention characteristics			
Average daily intervention size in percent of GDP	0.274***	0.153**	0.146**
	(0.102)	(0.077)	(0.064)
Intervention with prior 2 weeks' trend (0/1)	0.094***	-0.067**	0.014
	(0.015)	(0.028)	(0.012)
Intervention towards fundamental	0.004***	0.000	-0.005***
(based on distance to 3Y-MA)	(0.001)	(0.001)	(0.001)
Share of max. local volatility	-0.038	0.214***	-0.548***
	(0.042)	(0.052)	(0.042)
Communication			
Any oral intervention (0/1)	0.087***	-0.079***	-0.059***
	(0.018)	(0.024)	(0.013)
Turbulent time (0/1)	-0.057	-0.128*	-0.053
	(0.041)	(0.074)	(0.044)
Oral intervention (0/1) x Turbulent time (0/1)	0.133**	0.170**	-0.063
	(0.060)	(0.085)	(0.055)
Adj. R^2	0.377	0.802	0.811
Observations	4,549	1,787	4,549

Notes: The event criterion defines success as movement of the exchange rate during the intervention that is consistent with the intervention's effect on the exchange rate. The smoothing criterion counts a reduction in the absolute slope during the event and for the next week compared to the week before the event as success. The sample size for the smoothing criterion is lower because it is only defined for interventions against the one week trend. The stabilization criterion counts success as the exchange rate staying within a 2 percent band during the event and during the next 2 weeks. Currency regime fixed effects are dummy variables based on the Reinhart and Rogoff (2004) classification. See Table A14 for a this setup estimated by logit and Table A6 for specification without interaction terms for turbulent times. Heteroskedasticity-robust standard errors in parentheses. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively.

Table 7: *Matching events and placebo events by country on misalignment and previous FX change*

	(1)	(2)	(3)	(4)	(5)	(6)
Criterion	Event	Smoothing	Smoothing	Stabilize	Smoothing	Stabilize
Regime	Free Floater	Free Floater	Broad Band	Broad Band	Narrow Band	Narrow Band
Estimator	nn-match	nn-match	nn-match	nn-match	nn-match	nn-match
Average Treatment Effect	0.250***	0.329***	0.267***	-0.001	0.347***	0.104***
on the Treated	(0.067)	(0.112)	(0.094)	(0.079)	(0.060)	(0.015)
Observations	18,533	9,556	25,940	28,376	17,671	25,556

Notes: Nearest neighbor matching with bias correction using, as suggested by Table A8, the lagged absolute misalignment from the 5, 3 and 1 year moving average (uncentered, previous year) of the exchange rate and the absolute change in the exchange rate leading to the previous day. Exact matching within country is used resulting in some observations that cannot be matched and which are excluded. The placebo intervention episodes are designed to have the country-specific median length of the intervention episodes and the length is accounted for in the matching procedure. *, **, and *** indicate significance at the 10, 5 and 1 percent level, respectively. The number of observations indicates first days of intervention episodes plus the number of days that are not part of an intervention episode and for which placebo events are calculated.